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SOUTH BAY TIDAL MARSH STUDIES
TECHNICAL DISCUSSION

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INTRODUCTION

Conversion of pickleweed (*Salicornia virginica*) and cordgrass (*Spartina foliosa*)-dominated salt marsh habitats to brackish marsh habitats is of concern in the South San Francisco Bay because numerous studies indicate that salt marsh is the preferred habitat for two endangered species, the California Clapper Rail (*Rallus longirostris obsoletus*) and the salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*) (Larry Walker Associates 1989). The abundance of these two listed species has generally declined with the bay-wide loss of habitat since the 1850's. Estimates of tidal marsh loss in San Francisco Bay indicate that there were approximately 40,000 acres of tidal marsh in 1850 and approximately 4700 acres in 1989, nearly 4,000 acres of which were characterized as salt marsh (Larry Walker Associates 1989).

Large-scale changes in the remnant marshes of South San Francisco Bay were first recognized in the 1970's. Marsh observations indicated that salt marsh habitat had converted to brackish marsh habitat. Studies, conducted during the 1970's and 1980's, confirmed that marsh conversion was real and was accompanied by new marsh formation (Harvey and Stanley Associates 1984). It is assumed that changes from salt to brackish marsh vegetation will reduce the use of this habitat by the California Clapper Rail and salt marsh harvest mouse (Larry Walker Associates 1989).

Early studies pointed toward the influence of freshwater discharges on marsh conversion observed in the South Bay. The largest source of freshwater discharge during the dry season in the South Bay is the San Jose/Santa Clara Water Pollution Control Plant (WPCP). The Regional Water Quality Control Board (RWQCB) issued a Cease and Desist Order to the Cities of San Jose and Santa Clara (both of which operated the WPCP) on January 18, 1989. The Cease and Desist Order required the Cities to mitigate for their impacts to salt marsh habitat and reduce dry season discharges at the WPCP.

Although several studies were prepared between 1985 and 1989 in an attempt better understand and mitigate for habitat losses, the Cease and Desist Order and further negotiations with RWQCB prompted the City of San Jose to begin a new series of studies that both monitored the vegetation changes in the marshes of the South San Francisco Bay and determined the causal mechanisms behind the observed changes. These studies included a marsh conversion study reviewing aerial photos dating back to 1970, detailed vegetation mapping of the marshes in the South Bay from 1989 to 2001, hydrologic models of Coyote Creek and the comparison between all discharges in the South Bay and continuous water levels and salinity data and selected edaphic characteristics collected between 1999 and 2001. A study of the Historical Perspective and the relationship to freshwater influences was also prepared for the City of San Jose (San Francisco Estuary Institute, 1999).

This report provides an overview of the data collected in the studies commissioned by the City of San Jose. We will summarize that data, review historical changes to the South Bay Marshes and present the best possible explanation for the large-scale changes observed in the South San Francisco Bay marshes.

PHYSICAL SETTING

The San Francisco Bay ecosystem has been highly altered by human activities. These alterations have led to the loss of most of the tidal wetlands in San Francisco Bay (Atwater et al. 1979). Diking of marshes for salt production is the main cause for the historic marsh loss in South San Francisco Bay. Diking of the South Bay marshes began in the 1920's and 1930's and was completed by the mid to late 1950's. Furthermore, groundwater extraction in the South Bay, for both drinking water and agricultural use, caused very high rates of subsidence. Specifically, localized subsidence around downtown San Jose and the Alviso area was as great 13 feet (CH2MHill 1989b). Groundwater recharge and the cessation of groundwater pumping mostly halted the subsidence in the South Bay by 1970.

Historically (early-mid nineteenth century) the most significant sources of freshwater discharge to the South Bay were from the large distributaries (SFEI 1999). Coyote Creek, Guadalupe River and San Francisquito Creek were the largest channels discharging to the South Bay. The discharge from many of the smaller channels spread out on the alluvial plain behind the tidal marshes and did not actually discharge directly into the coastal marshes (SFEI 1999). Groundwater discharge and direct precipitation also likely influenced the salinity of coastal marshes (SFEI 1999).

Two major channels currently discharge into the South Bay, Coyote Creek (average annual discharge ~ 85 cfs or 55 mgd) and the Guadalupe River (average annual discharge ~ 70 cfs or 45 mgd). Furthermore, other sources of freshwater are present within the region. The San Jose/Santa Clara Water Pollution Control Plant (WPCP) provides continuous freshwater discharge of approximately 185 cfs (120 mgd). The Sunnyvale WPCP average effluent discharge is approximately 28 cfs (18 mgd) and the Palo Alto WPCP average discharge is approximately 50 cfs (32 mgd) (CH2MHill 1990). Artesian springs are present in and around Alviso and may also be present within portions of the South Bay marshes, however these features are not well documented.

Since the completion of diking of the tidal salt marshes and the cessation of subsidence in the South Bay, channels have been filling with sediments. Based on our review of historical and recent aerial photography, many areas that were once open water (e.g. Artesian Slough, Alviso Marina) have filled with sediment and converted to marsh since the early 1970's. As recently as the late 1960's, barges were able to reach Alviso via Alviso Slough (Tom Lane, personal communication). Channels such as Alviso Slough have filled significantly and subsequently have a much smaller cross sectional area than in the early 1970's.

A combination of factors has been changing the bathymetry of the channels and increasing the area of tidal marsh between the slough channels and the salt pond levees. These factors include the high concentration of suspended sediments, the decrease in tidal channel velocities associated with the diking of the salt marshes and the overall cessation of subsidence. The tidal channels of the South Bay are currently adjusting to a size that directly relates to the reduced tidal area that is now drained (tidal prism). Furthermore, non-native cordgrass (*Spartina alterniflora*) and its hybrids, which are present in the South Bay, are more flood tolerant than native cordgrass and could be growing at lower elevations along slough channels further decreasing the tidal channel size. Substantially smaller tidal channels (that lack the historical drainage network) decrease the tidal range at their upstream ends. As the tidal range decreases, the relative marsh surface elevation also changes. Therefore marsh surface elevations farther upstream (away from the Bay) are lower than marshes near the mouth of the Bay (H. T. Harvey & Associates 2001b, SFEI 1999).

SUMMARY OF 1989 STUDIES

CH2MHill prepared several studies for the City of San Jose related to the Cease and Desist Order from the RWQCB and as part of Provisions E3 and E5D of the NPDES permit. These studies both accounted for the area of marsh conversion since 1970 and estimated the portion of the change related to increased discharge by the WPCP. Overall, the studies indicated that salt marsh habitat has converted to brackish marsh habitat in Coyote Creek, Alviso Slough, Warm Springs marsh (Upper Mud Slough) and Albrae Slough (CH2MHill 1989a, CH2MHill 1989b). Furthermore, the studies determined that the WPCP was responsible for the observed salt marsh conversion along Coyote Creek, but was not responsible for the conversion observed in Alviso Slough, Warm Springs marsh or Albrae Slough (CH2MHill 1989b).

CH2MHill (1989a) determined that between 115 and 162 acres (difference based on methodology) of salt marsh vegetation converted to other habitat types between 1970 and 1985 in the Coyote Creek study area. Additional conversion occurred in Alviso Slough, Warm Spring marsh and Albrae Slough. Within that same time period CH2MHill (1989a) found that marsh area in the Coyote Creek study area increased by 200 acres. Salt marsh conversion in Coyote Creek, Albrae Slough and Mud Slough all occurred in the middle portion of the channels; much of the upper reaches of these channels were already brackish marsh habitat prior to 1970 (CH2MHill 1989a).

CH2MHill also collected substantial physical data from the system. Discharges from Coyote Creek and Guadalupe River were highly variable between 1970 and 1987, however the streamflows averaged 85 cfs and 70 cfs for Coyote Creek and the Guadalupe River, respectively (CH2MHill 1989b). Rainfall patterns are also quite variable; however, a noted decline in rainfall quantities has occurred since 1919. Both significant streamflow events and droughts occurred between 1970 and 1987. The largest streamflow events occurred in 1982 and 1983; two droughts occurred between 1975-1977 and 1986-1989 (CH2MHill 1989b). However, average streamflow and salt marsh vegetation decline did not correlate strongly during the 1970 – 1987 time period (CH2MHill 1989b).

The WPCP is the predominant wastewater discharger in the South Bay. The WPCP began operating in 1956 as a primary treatment plant (CH2MHill 1989b). Other wastewater discharges were historically located in the South Bay including the Union Sanitary District Irvington and Milpitas discharges. The Union Sanitary Irvington discharge was rerouted to the lower San Francisco Bay in 1982 and the Milpitas discharge was rerouted to the WPCP in 1973 (CH2MHill 1989b). Flows from the WPCP increased through time at a linear rate until 1986 when flows began to level off at 120 mgd (185 cfs) (CH2MHill 1989b).

High sedimentation rates are well documented in San Francisco Bay. Since 1850, nearly 10,000 acres of land has been added to Bay fringes (CH2MHill 1989b). An analysis of sedimentation rates in the study area during a 28-year period (1956-1984) indicated that

0.32 feet/year of deposited material was added (9 feet total) in lower Coyote Creek and 0.14 feet/year of deposited material (4 feet total) was added in the middle reach of Alviso Slough (CH2MHill 1989b). During the same time period there was approximately 2-3 feet of subsidence, however most of that subsidence occurred between 1956 and 1970 (approximately 0.21 to 0.29 feet/year). No significant subsidence has occurred since 1970 (CH2MHill 1989b). Observations of channel size further indicated that sedimentation had produced a pronounced narrowing of Mud Slough and the north side of Coyote Creek between Albrae Slough and Calaveras Point (CH2MHill 1989b).

The high rate of sedimentation and the subsequent decrease in channel volume has had a marked affect on the tidal prism and surface water salinity in the South Bay channels. CH2MHill (1989b) found that a significant reduction in tidal prism has occurred in Coyote Creek. Between 1956 and 1984, the tidal prism in Coyote Creek between Drawbridge and Calaveras Point had declined by 116 million cubic feet, a loss of about 26% of the 1956 channel volume (CH2MHill 1989b). This change is directly related to the high rates of sedimentation and the reduction in local subsidence in the area (CH2MHill 1989b).

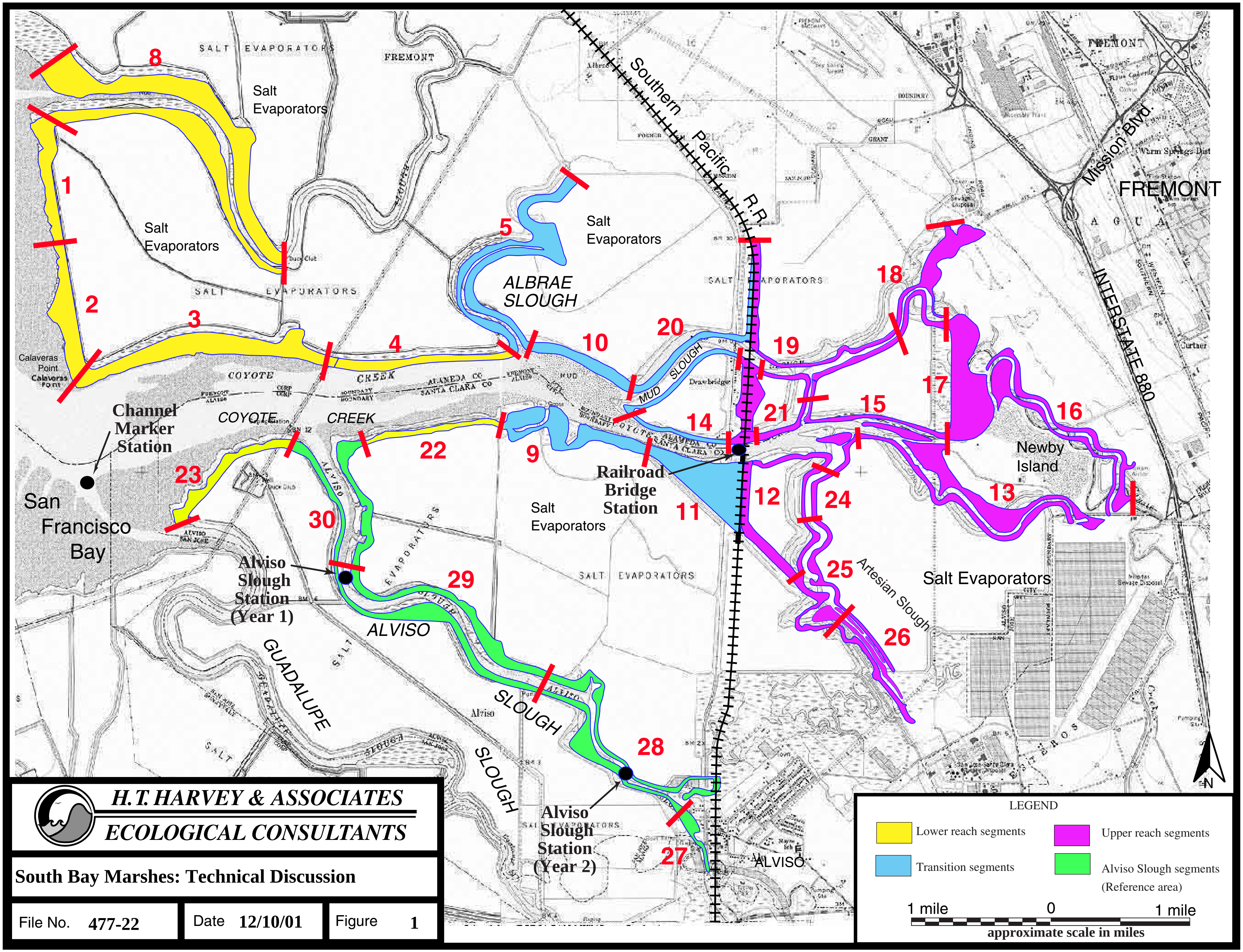
SUMMARY OF STUDIES CONDUCTED FROM 1989-2001

Detailed vegetation mapping of the South Bay Marshes was conducted in 1989, 1991, 1994/95, 1996 1997, 1998, 1999, 2000 and 2001 (H. T. Harvey & Associates 2001a). The 1989 and 1991 mapping were done on color aerial photographs at a scale of 1" = 500' (H. T. Harvey & Associates 1989; CH2Mhill 1991). All subsequent mapping was done on color infrared (CIR) photos at 1" = 200' (H. T. Harvey & Associates 1994, 1995, 1997, 1998, 1999, 2000 and 2001a). Beginning in 1994, all field vegetation maps were digitized and acreage calculations by plant associations, dominant species and habitat type were done in GIS and maps were produced. Beginning in 1999, digital ortho photos were used for all field mapping to further improve the mapping accuracy (H. T. Harvey & Associates 1999). These baseline (1989) data were also digitized and rectified to the 2001 ortho images.

Mapping of the South Bay Marshes included all the area potentially affected by the WPCP effluent (Coyote Creek, Mud Slough, Albrae Slough), Mowry Slough and Alviso Slough (Figure 1). Alviso Slough receives freshwater discharge from the Guadalupe River. Furthermore, past changes observed in marsh vegetation in Alviso Slough were not caused by freshwater flows from the WPCP (CH2MHill 1989a). Therefore Alviso Slough is used as a Reference Area for habitat change not associated with WPCP affects.

New marsh formation and marsh conversion is annually variable. Some annual plant species such as spearscale (*Atriplex triangularis*) are quite common as a dominant plant species in the study area during some years (e.g. 1997) but are only subdominant or minor components of the marsh in other years. However, since 1989 there has been a trend of new marsh forming and salt marsh converting to brackish marsh habitats in both the study area and the reference area (Appendix A).

Very little new marsh formation occurred between 1989 and 1996 and between 1999 and 2001. However between 1996 and 1999 almost 200 acres of new marsh formed in the study area (H. T. Harvey & Associates 2001a). This sporadic marsh formation has been attributed to rapid mudflat colonization by both salt and brackish marsh plant species. High rates of sedimentation likely raise mudflats to a critical elevation that will support wetland plant species. When that critical elevation is reached, the mudflats are rapidly colonized by plants (H. T. Harvey & Associates 2001a). Currently, large mudflats along Coyote Creek near the confluence of Alviso Slough appear to be near the elevations that will allow plant species to colonize; some cordgrass (*Spartina* sp.) has recently been seen on these mudflats (Eric Webb, pers. obs.). H. T. Harvey & Associates (2001a) predicted that these mudflats will soon be colonized by wetland plant species and large areas of new marsh will be found in the study area within the next several years.



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South Bay Marshes: Technical Discussion

File No. 477-22 | Date 12/10/01 | Figure 1

The overall area of salt marsh within the study area has remained relatively constant since 1989. However salt marsh conversion to brackish marsh habitats has been relatively dramatic (98.9 acres converted since 1989). This indicates that new salt marsh formation is occurring at approximately the same rate as salt marsh conversion in the study area (H. T. Harvey & Associates 2001a). Furthermore, it also indicates that some of the new marsh formation occurs as brackish marsh habitats.

The rate of salt marsh conversion in the reference area was substantially higher than the rate of conversion in the study area between 1989 and 2001 (H. T. Harvey & Associates 2001a). Although this may be confounded by the fact that the reference area is significantly smaller than the study area, these data indicate that marsh conversion occurs throughout the South Bay, not just in marshes directly affected by the WPCP discharge (H. T. Harvey & Associates 2001a). This also indicates that much of the conversion of salt marsh habitats within the South San Francisco Bay area was likely driven by large-scale influences that were affecting the entire system.

H. T. Harvey & Associates (2001a) found that the WPCP has had a dramatic influence upon the plant species distribution in Artesian Slough. This waterway dead ends at the discharge point for the WPCP and is now freshwater marsh habitat. Without the WPCP discharge it was predicted that Artesian Slough would consist of a mixture of brackish and salt marsh habitats (H. T. Harvey & Associates 2001a). However, between 1989 and 2001 only minimal conversion of salt marsh to brackish marsh habitat occurred in the marshes of Coyote Creek downstream of Albrae Slough (H. T. Harvey & Associates 2001a). Therefore it is assumed that the influence of the WPCP discharge does not extend much beyond Albrae Slough.

Surface water salinity and soil interstitial salinity data collected between 1999 and 2001 in the study area supports this hypothesis (H. T. Harvey & Associates 2001b). The data showed that soil salinities and surface water salinities during the dry season remain relatively high within the marshes of Coyote Creek downstream of Albrae Slough compared to the rest of the study area (H. T. Harvey & Associates 2001b).

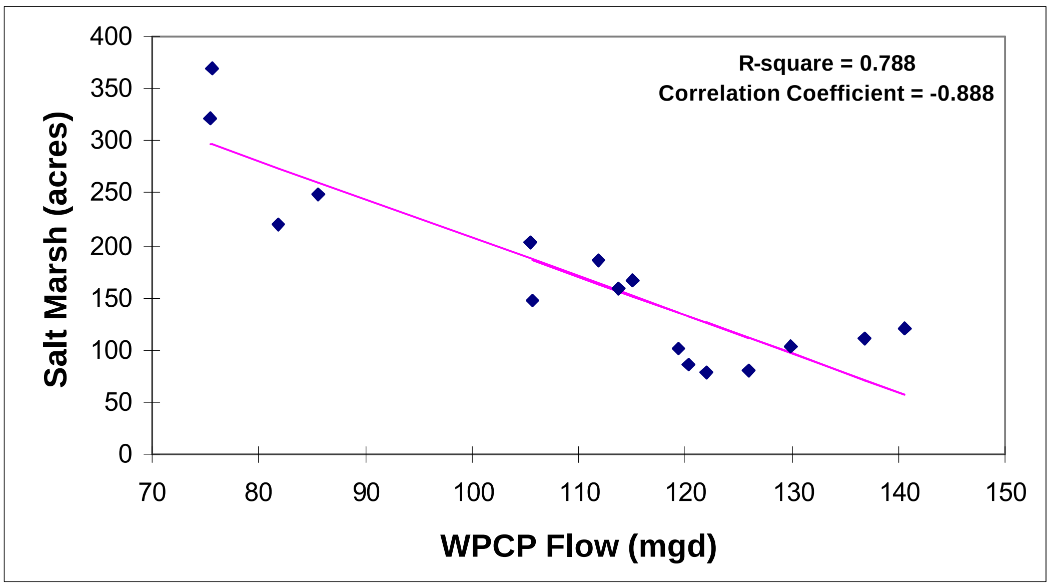
Soil salinity and bulk density were found to be correlated with habitat type. Areas mapped as salt marsh have the highest soil salinities and bulk densities; areas mapped as freshwater marsh have the lowest soil salinities and bulk densities (H. T. Harvey & Associates 2001b). Areas mapped as brackish marsh habitat have soil salinity that is intermediate between the other two habitat types and bulk density that is similar to salt marsh habitat (H. T. Harvey & Associates 2001b).

The physical data collected between 1999 and 2001 also indicate that the reference area was most like the marshes of Coyote Creek and Mud Slough upstream of the Railroad crossing (H. T. Harvey & Associates 2001b). This portion of the study area has the lowest soil salinities and largest area of brackish and freshwater marsh habitats (H. T. Harvey & Associates 2001a, b).

MARSH CONVERSION REGRESSION ANALYSIS

A regression analysis was performed in 1989 between mean annual effluent from the WPCP (mgd) and salt marsh acreage for marshes upstream of Albrae Slough (segments 9-21 and 24-26 (see Figure 1)). These segments were selected because in 1989, they were the only segments where conversion had been observed. The regression analysis was updated in 1998 and still showed a significant correlation (R-square = 0.84). The regression analysis was repeated using the additional data collected from 1999 to 2001. Flow data were calculated as a yearly mean for the 12 months preceding the corresponding vegetation sampling. The updated regression analysis results also indicate a significant correlation (R-square = 0.79) between marsh acreage in the selected segments and WPCP flow through time (Figure 2). However, the correlation was weakened by the addition of the last three years of data.

Figure 2. Regression analysis plot (with best fit line) of mean annual flows and salt marsh acreage from 1970 - 2001.

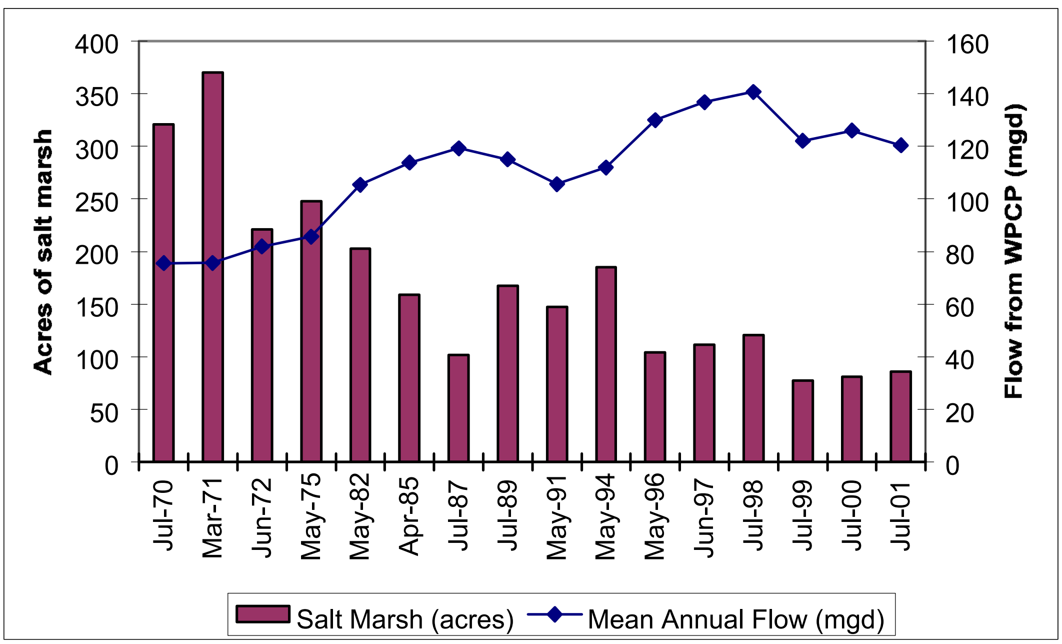


In this linear regression analysis, it is assumed that marsh acreage is the dependent variable and that WPCP flows are the independent variable. This model would then presume that the amount of salt marsh acreage could be predicted based upon quantity of WPCP effluent. While the correlation appears strong, it should be noted that there are numerous other independent variables that are contributing to the nature and composition of the marsh vegetation. A strong correlation does not indicate causality.

The slight upward trend toward the high outflow end (approximately 120 mgd or greater) of the regression curve appears to indicate that the salt marsh acreage within these segments has approached some sort of equilibrium point (Figure 2). By 1995, much of the salt marsh in these segments has converted to brackish marsh, and the slight variations observed in subsequent years can be attributed to general inter-annual variability. Further analysis of the more recent WPCP outflow and salt marsh conversion data would have to include a larger geographic area than the segments utilized for this regression analysis.

There have also always been concerns about the accuracy of the early (pre-1989) data used annually in calculating marsh acreage. These data were prepared in 1989 from a variety of historic photos of different scales and quality. The error associated with interpretation of historic photography was much higher than that of the more recent work. Figure 3 illustrates that there appears to be dramatic interannual change in salt marsh acreage. For example, it appears this portion of the South Bay marshes lost about 150 acres of salt marsh from March 1971 to June 1972. Teasing out what changes are real, and what changes are a result of mapping inconsistencies can be difficult. For example, the decrease in salt marsh acreage between 1998 and 1999 can be attributed to either the beginning of the use of orthorectified photography, or the result of true marsh conversion from the high rainfall associated with El Niño in 1998. High rainfall years in 1995 and 1984 also contribute to the decrease in total salt marsh acreages in subsequent years (Figure 3).

Figure 3. Salt marsh acreage and mean annual flow from WPCP.



To determine the strength of the relationship between these two variables, we also performed a linear correlation, which resulted in a strong negative relationship (r = -0.89). R-square is an indication of the proportion of the total variability in the salt marsh acreage that can be accounted for in the outflow data. The correlation coefficient (r) is a measure of the strength of that relationship. A correlation coefficient that is less than 0 indicates a negative linear relationship. However, the biological relevance of these analyses should not be overstated.

CAUSES OF MARSH CONVERSION

A number of variables are important in controlling the distribution of plant species in coastal marshes. These variables include interstitial soil salinity (Callaway and Sabraw 1994, Allison 1992, Callaway et al. 1989, Zedler 1983, 1986), depth and duration of flooding over the marsh surface (Webb and Mendelssohn 1996, Webb et al. 1995, Pennings and Callaway 1992, Mendelssohn and McKee 1988), accumulation of phytotoxins such as hydrogen sulfide in marsh soils (Webb and Mendelssohn 1996, Webb et al. 1995, Koch and Mendelssohn 1989, DeLaune et al. 1983, King et al. 1982), interstitial nutrient concentrations (Boyer et al. 2001, Koch et al. 1990, Bradley and Morris 1980, Koch and Mendelssohn 1989, Morris 1980), interspecific competition (Grace and Wetzel 1981, Zedler 1982, Bertness 1991) and soil mineral and organic matter content (Nyman et al. 1990, DeLaune et al. 1979). All of these variables can be affected by both natural and man-induced environment changes such as changes in precipitation, sea level and anthropogenic (potentially nutrient-rich) freshwater discharges.

In the study area, a strong relationship between plant species composition and interstitial soil salinity was found (H. T. Harvey & Associates 2001b). Furthermore, freshwater marsh areas had lower soil bulk densities and had a lower average marsh plain elevation (H. T. Harvey & Associates 2001b). The data indicate that freshwater influences are most strongly related to marsh conversion in the upper reaches of the study area and in the reference area. Therefore some of the change is directly related to increased freshwater flows from the WPCP, Coyote Creek, Guadalupe River and possibly the Delta.

However, freshwater influences may also be related to changes in channel morphology. The decrease in slough channel width and depth and subsequent new marsh formation since the early 1970’s in the study area is well documented (CH2MHill 1989a, H. T. Harvey & Associates 2001a). This change in channel volume has also likely been responsible for the decrease in tidal prism found at Alviso Slough and Coyote Creek (H. T. Harvey & Associates 2001b). High tides in the slough channels of the study and reference areas are significantly lower than predicted (~0.5 feet lower) and the low tides are higher than predicted. The marsh elevation farther upstream in the slough channels has responded to this change in tidal range; relative marsh elevations are lowest farther upstream. This reduction in tidal heights indicates a decrease in tidal influences further upstream. Therefore, since higher surface water salinities are ushered in during high tides (H. T. Harvey & Associates 2001b), a reduction in tidal height will likely correspond to a reduction in the salinity of the water flooding the marsh surface. Therefore the changes in channel morphology of the South Bay for the past 30 years explain a portion of the observed marsh conversion.

Freshwater inputs to the system are also important to the observed changes. Freshwater inputs to the system include the WPCP, Coyote Creek, Guadalupe River, Guadalupe Slough and the Sacramento/San Joaquin Delta. The WPCP provides the majority of the freshwater input to the system during the dry season but is a relatively smaller portion of the overall discharge during the winter and spring (H. T. Harvey & Associates 2001b).

For example, CH2MHill (1990) conducted a dilution study in the South Bay in September 1989 using dye injected into the WPCP discharge. The study showed that the minimum average water column dilutions increase with distance from the WPCP. Furthermore, observed dilutions in the middle reaches of Alviso and Guadalupe Sloughs were lower than at the confluence of these sloughs and Coyote Creek (CH2MHill 1990). The study also found that salinity and dilution were correlated. H. T. Harvey & Associates (2001b) indicate that surface water and interstitial salinity is lower throughout the system in the winter and spring. The marked increase in surface water and interstitial soil salinity only occurs in late summer and fall (H. T. Harvey & Associates 2001b).

The timing and volume of the discharges has important implications to the vegetation changes observed in the South Bay. For example, seasonal influences of salinity may control the distribution of alkali bulrush (*Scirpus robustus* and *S. maritimus*) in coastal wetlands of California. Alkali bulrush is the dominant plant species of brackish marsh habitats in the South Bay. Rapid growth of alkali bulrush during the spring may increase its competitive advantage over pickleweed and cordgrass during the high salinity summer periods (Ustin et al. 1982, Kantrud 1996). It is likely that the growth of alkali bulrush ceases during periods of high salinity (summer), but the corms survive (Kantrud 1996). In San Pablo Bay marshes, full canopy cover of pickleweed is developed by June; however, at that time cordgrass and alkali bulrush have incomplete canopy cover (Zhang et al. 1997). Studies in Southern California marshes indicate that extreme discharge events alter vegetation structure dramatically by allowing seeds of less salt tolerant plant species to germinate (Zedler and Beare 1986). Furthermore, if the plants grow to the rhizome stage they are able to persist following the return of hypersaline conditions (Zedler and Beare 1986). Alkali bulrush has been found growing in hypersaline conditions in the South Bay marshes (H. T. Harvey & Associates 2001a). However, alkali bulrush requires low salinity conditions for germination (Kantrud 1996). These conditions may be present in the South Bay during years with extremely high rainfall during the late winter/spring.

A combination of factors is responsible for the salt marsh conversion in the South Bay. High precipitation years and subsequent high discharge events allow the germination and seedling establishment of brackish and freshwater marsh plant species. Dry weather discharges from the WPCP allow the persistence of these species through normal and low rainfall years. Decreases in channel bathymetry and the reduction in high tide elevation exacerbate the effects of decreased salinity within the South Bay. Marsh conversion since 1970 in Artesian Slough has been blamed on the discharge from the WPCP (H. T. Harvey & Associates 2001a); however, conversion in Coyote Creek downstream of Albrae Slough is believed to be caused by Bay-wide changes (H. T. Harvey & Associates 2001a). Conversion in Alviso Slough (reference area for marsh conversion studies) could be influenced by freshwater from the WPCP due to re-entrainment of freshwater (CH2MHill 1990) and some conversion in these marshes as well as the marshes in Coyote Creek upstream of Albrae Slough may be directly linked to dry weather discharge from the WPCP. However, the discharge from the WPCP does not alone explain the changes. A multivariate explanation that includes other discharges, changes in channel bathymetry and WPCP dry weather discharge is required for the system.

REGIONAL WETLAND PLAN DEVELOPMENT

The San Francisco Bay Area Wetlands Ecosystem Goals Project prepared a report that outlines the vision for wetland habitats and management in the baylands of San Francisco Bay (Goals Project 1999). The Goals Project outlines key ecological design considerations such as the creation of large connected patches of tidal marsh, include natural features, establish managed salt ponds, establish natural transitions between baylands and adjacent upland habitats and provide upland buffers to protect wetlands from disturbance (Goals Project 1999). Habitat recommendations for the South Bay center around the restoration of continuous bands of tidal marsh habitat along the bayfront and to provide a large complex of managed salt ponds farther inland (Goals Project 1999). It is recognized that tidal marsh restoration will include both salt and brackish marsh habitats based upon the proximity of freshwater sources (Goals Project 1999).

Large-scale tidal wetland restoration in the South Bay will dramatically alter the slough channel sizes and tidal heights. Salt pond breaching for tidal restoration will need to be phased, likely beginning with the most interior of those salt ponds that are slated for restoration. There will be an initial re-sizing of existing slough channels as salt ponds are breached and greater volumes of water are exchanged through the channels. A second channel re-sizing will occur as the salt ponds fill with sediment and tidal marsh forms.

Because the existing slough channels would approach their historic bathymetry following the restoration of tidal marshes in the South Bay, the saltwater influence from San Francisco Bay would extend farther into the slough channels and across the marsh surface. Tidal exchange would be improved in the larger slough channels and the current effects of re-entrainment of freshwater would be reduced. Interior marshes would likely form as tidal salt marsh habitat dominated by pickleweed and cordgrass. Marshes adjacent to large slough channels and marshes farther upstream nearer to freshwater sources would form as brackish marsh habitat. Restoration of tidal marshes as envisioned by the Goals Project would more closely resemble historic conditions (SFEI 1999) than present conditions.

The habitats created would mostly be salt marsh, since the tidal marsh restoration efforts would be focused on salt ponds nearer the Bay and slough channel perimeter, leaving the most upstream areas as salt ponds. Furthermore, the data collected to date indicate that large-scale tidal marsh restoration in the South Bay would improve habitat conditions in the existing marshes by increasing the influence of saline waters from the Bay.

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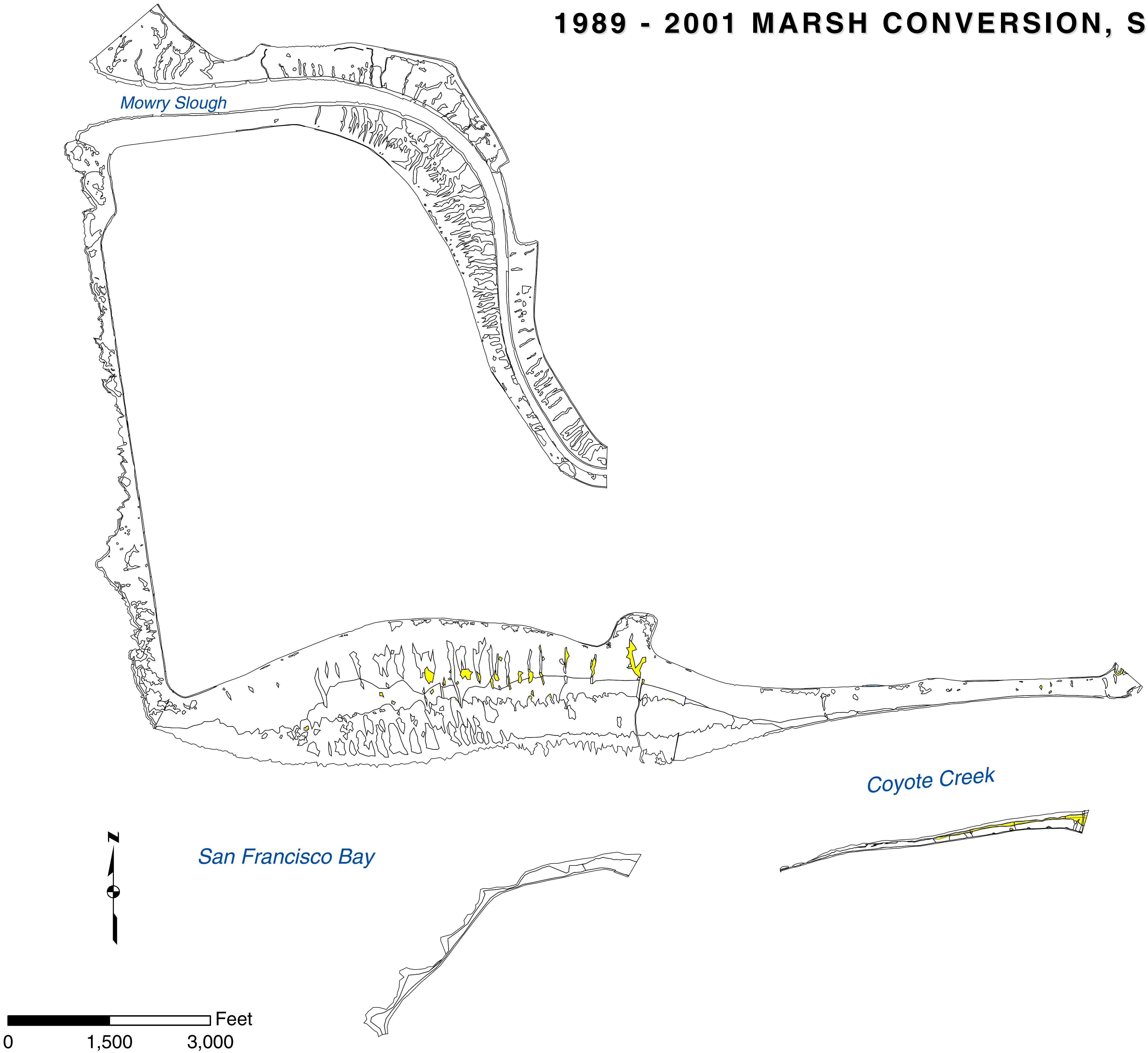
APPENDIX A:
HABITAT CONVERSION
AND MARSH GAIN FIGURES

1989 - 2001 MARSH CONVERSION, SOUTH SAN FRANCISCO BAY

LOWER REACH SEGMENT HABITATS

SEGMENTS 1, 2, 3, 4, 8, 22 and 23



Salt Marsh Converted to Brackish Marsh

Brackish Marsh Converted to Salt Marsh

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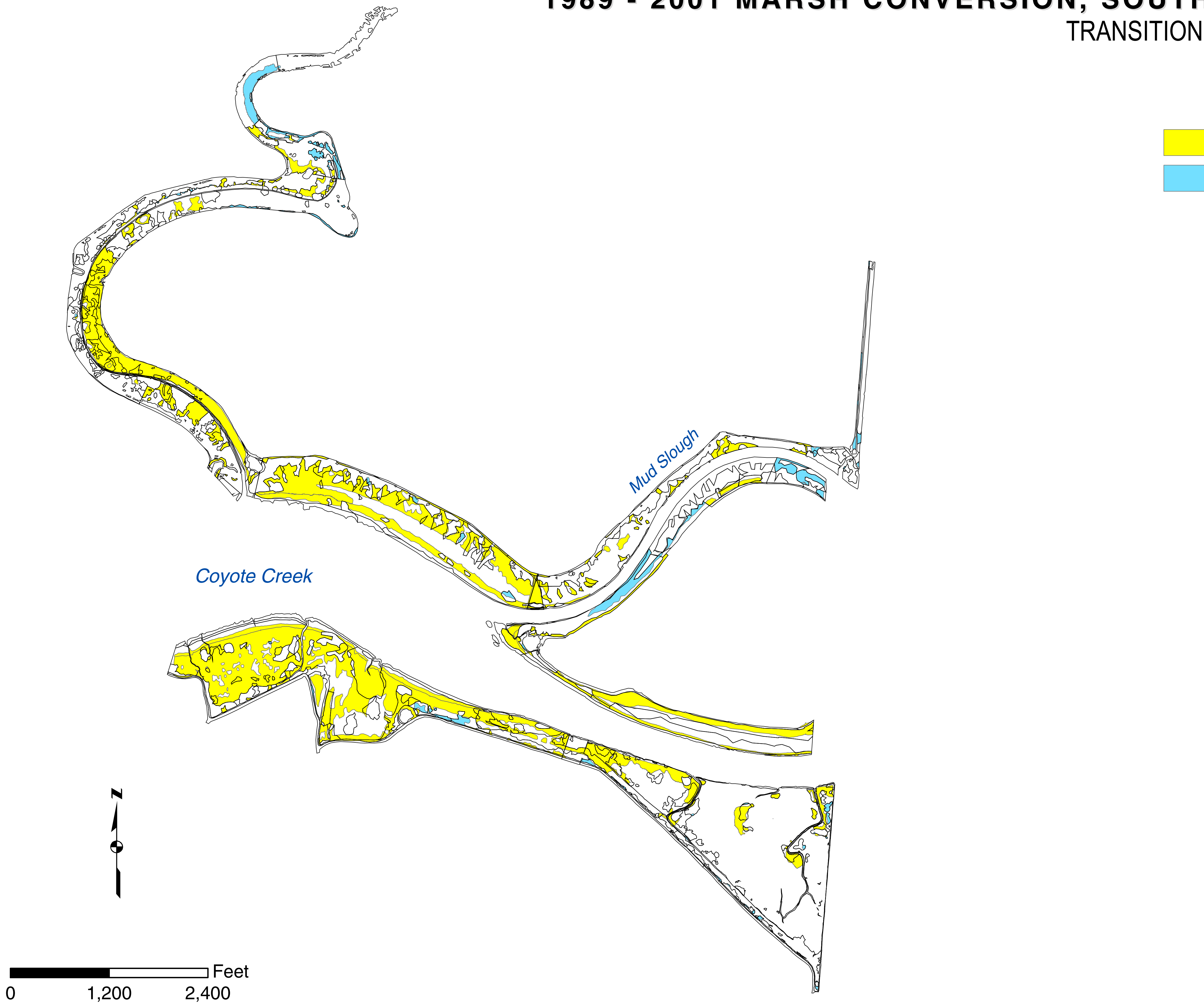
1989 - 2001 Marsh Conversion By Reach

File No. 477-22	Date 11/5/01	Figure 1

1989 - 2001 MARSH CONVERSION, SOUTH SAN FRANCISCO BAY

TRANSITION SEGMENTS DOMINANT SPECIES

SEGMENTS 5, 9, 10, 11, 14 and 20



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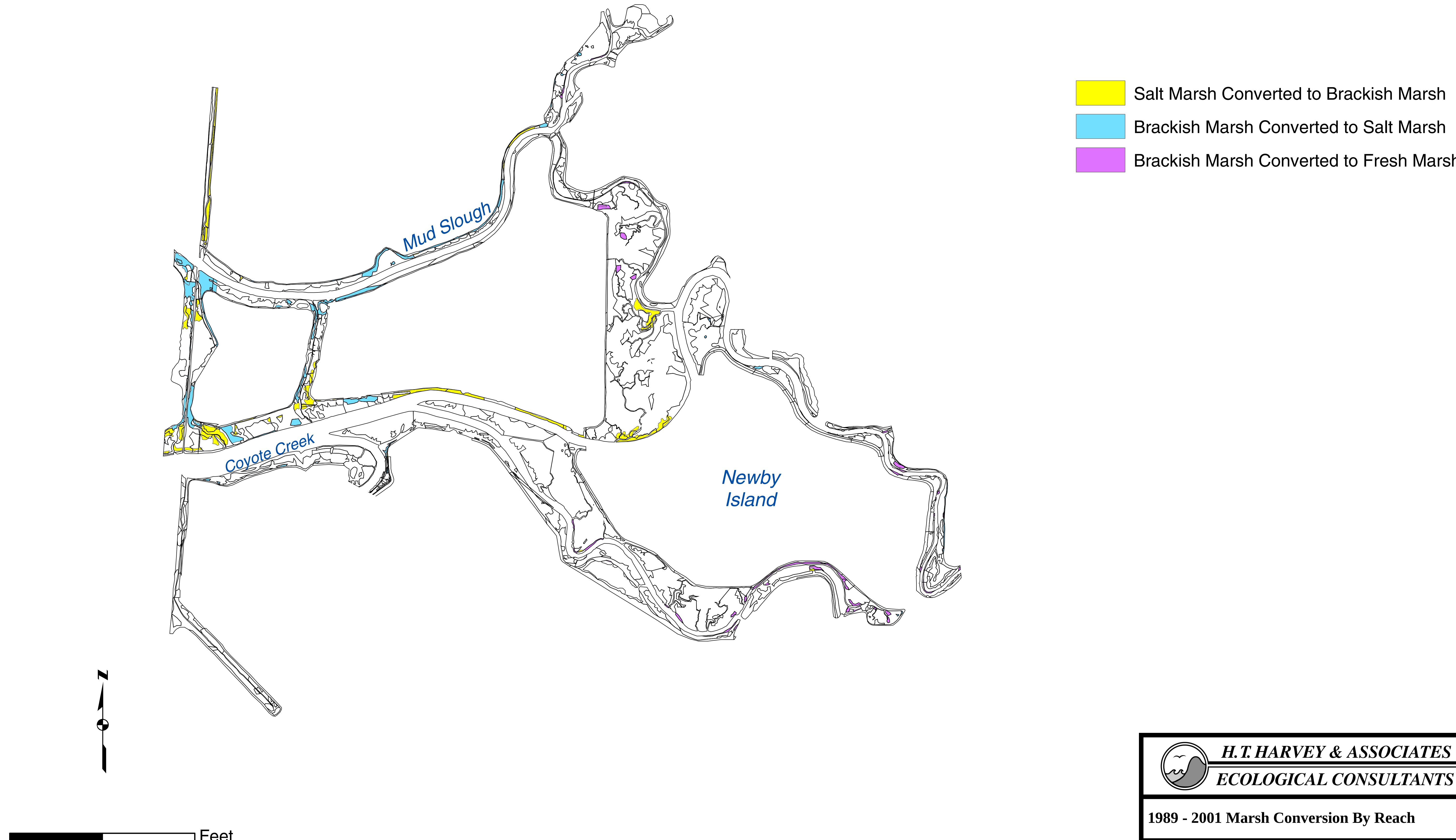
1989 - 2001 Marsh Conversion By Reach

File No. 477-22	Date 11/5/01	Figure 2

1989 - 2001 MARSH CONVERSION, SOUTH SAN FRANCISCO BAY

UPPER REACH SEGMENTS DOMINANT SPECIES

SEGMENTS 12, 13, 15, 16, 17, 18, 19 and 21



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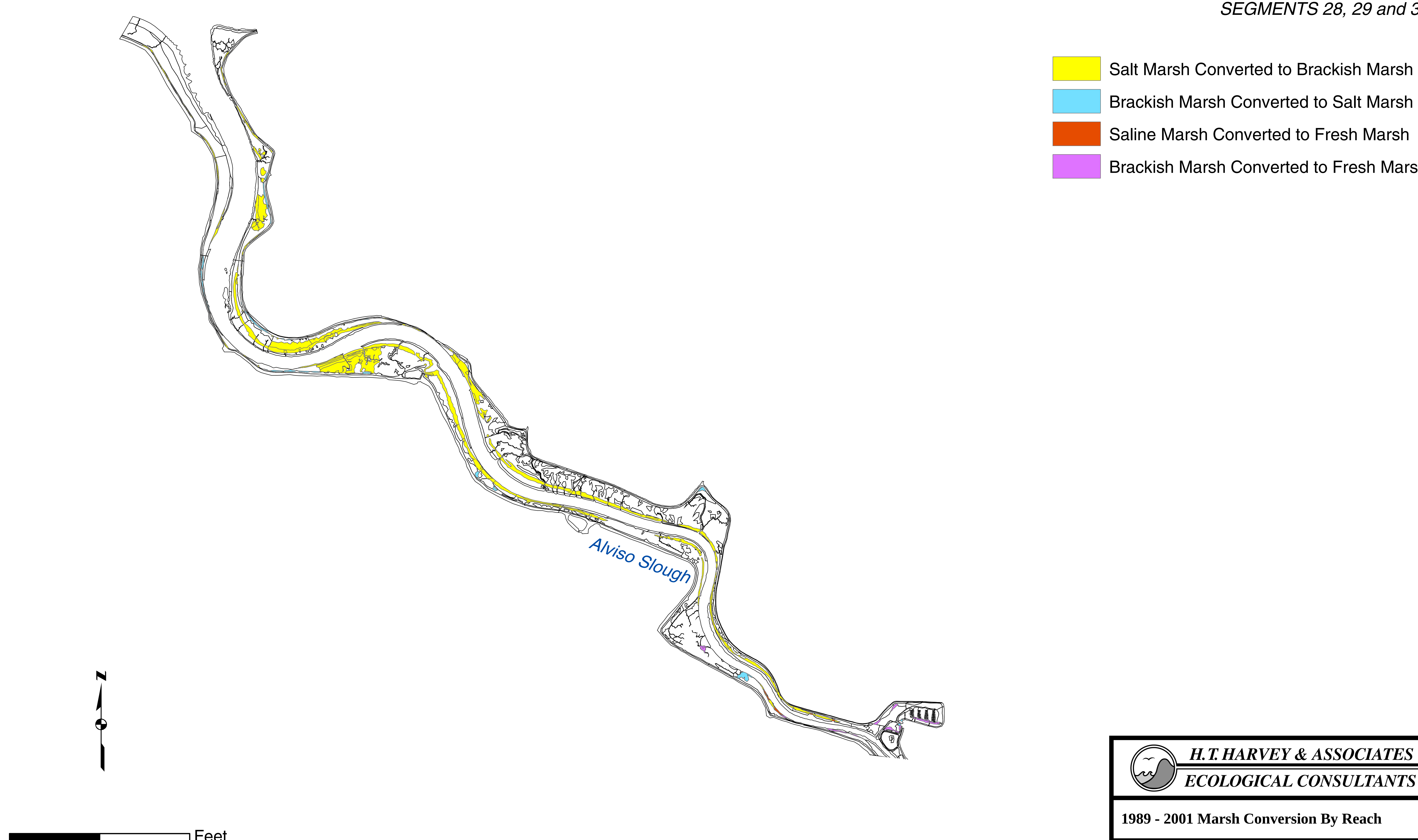
1989 - 2001 Marsh Conversion By Reach

File No. 477-22	Date 11/5/01	Figure 3

1989 - 2001 MARSH CONVERSION, SOUTH SAN FRANCISCO BAY

ALVISO SLOUGH SEGMENTS HABITATS

SEGMENTS 28, 29 and 30



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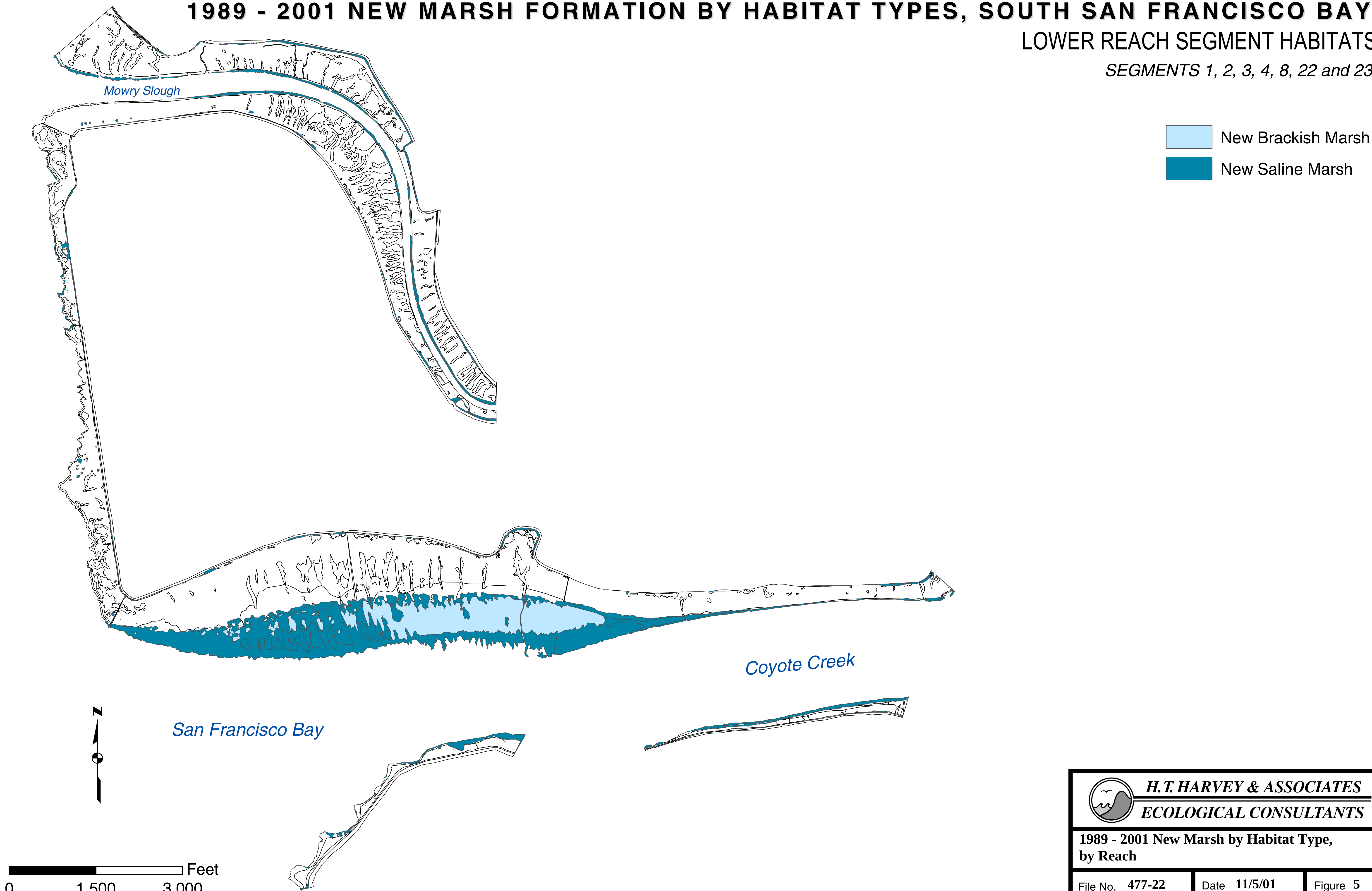
1989 - 2001 Marsh Conversion By Reach

File No. 477-22	Date 11/5/01	Figure 4

1989 - 2001 NEW MARSH FORMATION BY HABITAT TYPES, SOUTH SAN FRANCISCO BAY

LOWER REACH SEGMENT HABITATS

SEGMENTS 1, 2, 3, 4, 8, 22 and 23



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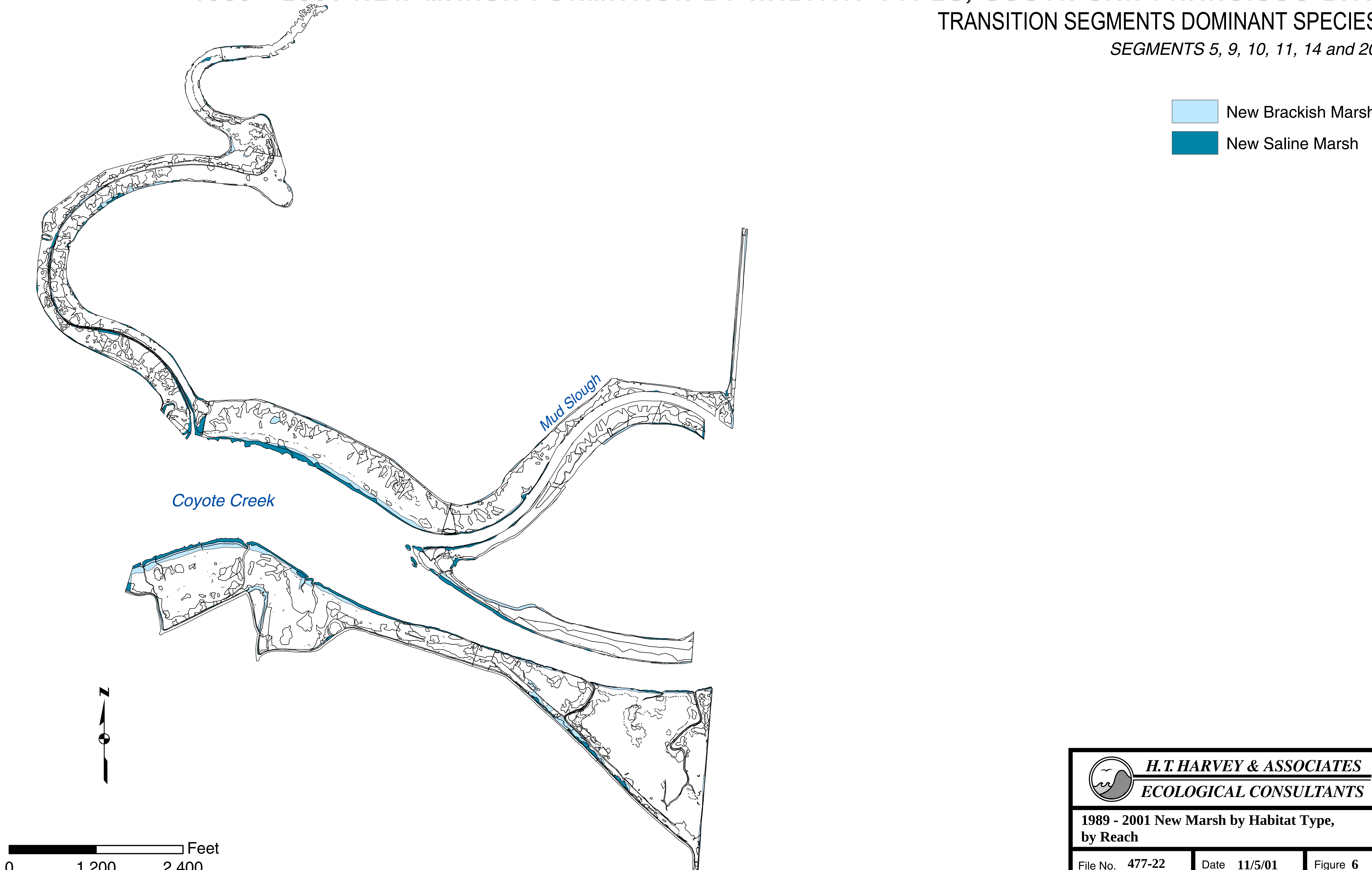
1989 - 2001 New Marsh by Habitat Type, by Reach

File No. 477-22 | Date 11/5/01 | Figure 5

1989 - 2001 NEW MARSH FORMATION BY HABITAT TYPES, SOUTH SAN FRANCISCO BAY

TRANSITION SEGMENTS DOMINANT SPECIES

SEGMENTS 5, 9, 10, 11, 14 and 20



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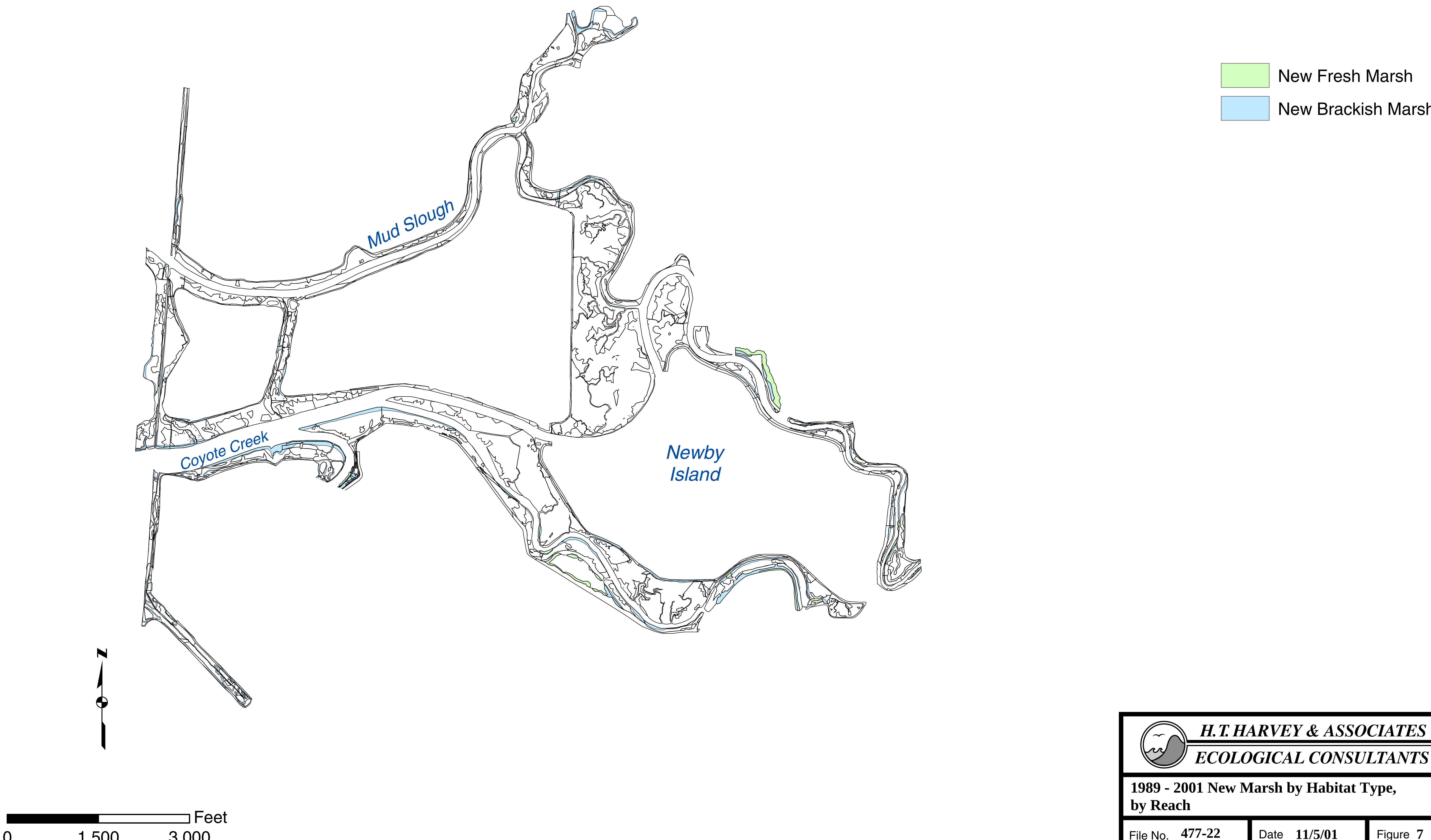
1989 - 2001 New Marsh by Habitat Type, by Reach

File No. 477-22	Date 11/5/01	Figure 6

1989 - 2001 NEW MARSH FORMATION BY HABITAT TYPES, SOUTH SAN FRANCISCO BAY

UPPER REACH SEGMENTS DOMINANT SPECIES

SEGMENTS 12, 13, 15, 16, 17, 18, 19 and 21



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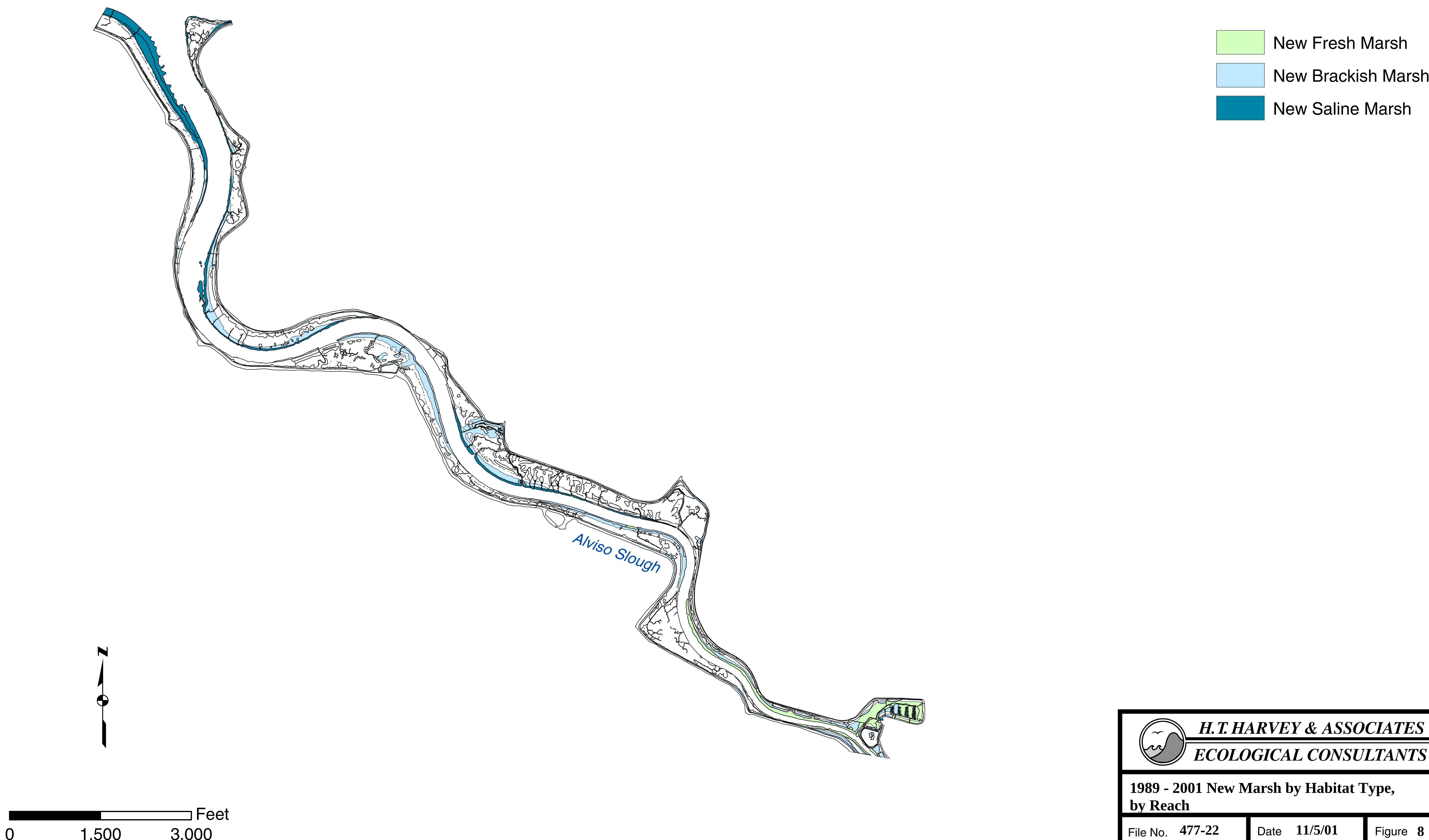
1989 - 2001 New Marsh by Habitat Type, by Reach

File No. 477-22	Date 11/5/01	Figure 7

1989 - 2001 NEW MARSH FORMATION BY HABITAT TYPES, SOUTH SAN FRANCISCO BAY

ALVISO SLOUGH SEGMENTS HABITATS

SEGMENTS 28, 29 and 30



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1989 - 2001 New Marsh by Habitat Type, by Reach

File No. **477-22**	Date **11/5/01**	Figure **8**